43 Determinate Statics

PRACTICE PROBLEMS

1. Two towers are located on level ground 100 ft (30 m) apart. They support a transmission line with a mass of 2 lbm/ft (3 kg/m). The midpoint sag is 10 ft (3 m).

(a) What is the midpoint tension?

(A) 125 lbf (0.55 kN)
(B) 250 lbf (1.2 kN)
(C) 375 lbf (1.6 kN)
(D) 500 lbf (2.2 kN)

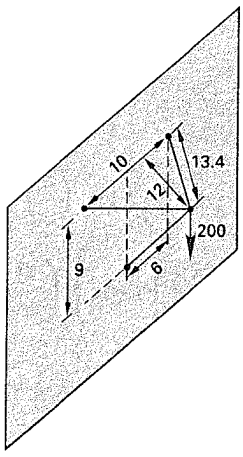
(b) What is the maximum tension in the transmission line?

(A) 170 lbf (0.70 kN)
(B) 210 lbf (0.86 kN)
(C) 270 lbf (1.2 kN)
(D) 330 lbf (1.4 kN)

(c) If the maximum tension is 500 lbf (2000 N), what is the sag in the cable?

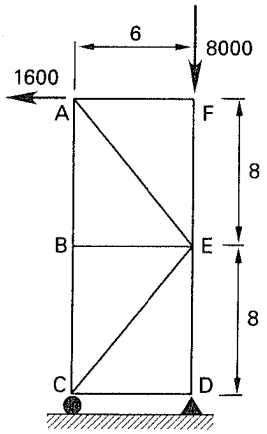
(A) 1.3 ft (0.4 m)
(B) 3.2 ft (1.0 m)
(C) 4.0 ft (1.2 m)
(D) 5.1 ft (1.5 m)

2. Two legs of a tripod are mounted on a vertical wall. Both legs are horizontal. The apex is 12 distance units from the wall. The right leg is 13.4 units long. The wall mounting points are 10 units apart. A third leg is mounted on the wall 6 units to the left of the right upper leg and and 9 units below the two top legs. A vertical downward load of 200 is supported at the apex. What is the reaction at the lowest mounting point?



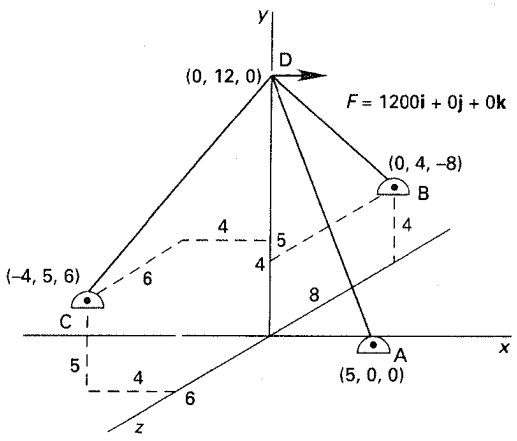
(A) 120
(B) 170
(C) 250
(D) 330

3. The ideal truss shown is supported by a pinned connection at point D and a roller connection at point C. Loads are applied at points A and F. What is the force in member DE?



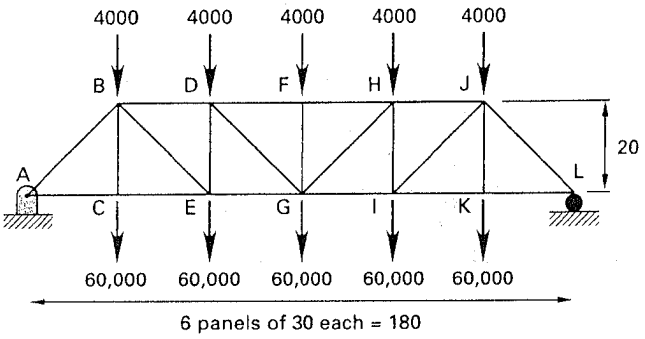
(A) 1200
(B) 2700
(C) 3300
(D) 3700

4. A pin-connected tripod is loaded at the apex by a horizontal force of 1200 as shown. What is the magnitude of the force in member AD?



(A) 1100
(B) 1300
(C) 1800
(D) 2500

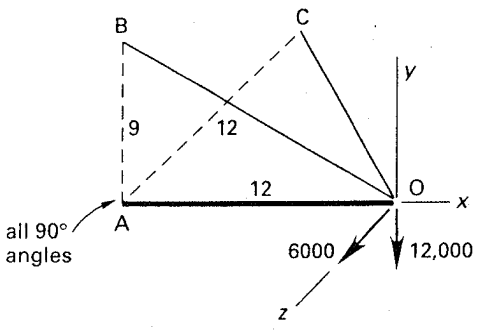
5. A truss is loaded by forces of 4000 at each upper connection point and forces of 60,000 at each lower connection point as shown.



(a) What is the force in member DE?
(A) 36,000
(B) 45,000
(C) 60,000
(D) 160,000

(b) What is the force in member HJ?
(A) 24,000
(B) 60,000
(C) 160,000
(D) 380,000

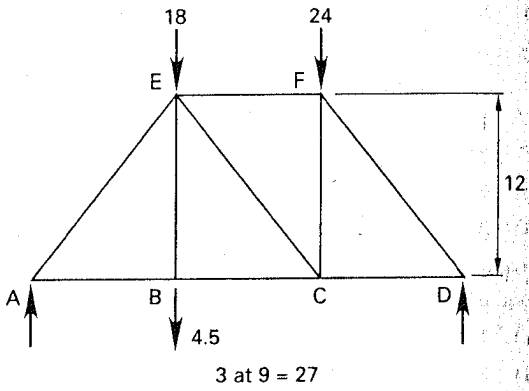
6. The rigid rod AO is supported by guy wires BO and CO, as shown. (Points A, B, and C are all in the same vertical plane.) Vertical and horizontal forces are 12,000 and 6000, respectively, as carried at the end of the rod. What are the x-, y-, and z-components of the reactions at point C?



(A) $(C_x, C_y, C_z) = (0, 6000, 0)$
(B) $(C_x, C_y, C_z) = (6000, 0, 6000)$
(C) $(C_x, C_y, C_z) = (6000, 0, 4200)$
(D) $(C_x, C_y, C_z) = (4200, 0, 8500)$

7. When the temperature is 70°F (21.11°C), sections of steel railroad rail are welded end to end to form a continuous, horizontal track exactly 1 mi long (1.6 km). Both ends of the track are constrained by preexisting, installed sections of rail. Before the 1 mi section of track can be nailed to the ties, however, the sun warms it to a uniform temperature of 99.14°F (37.30°C). Laborers watch in amazement as the rail pops up in the middle and takes on a parabolic shape. The laborers prop the rail up (so that it does not buckle over) while they take souvenir pictures. How high off the ground is the midpoint of the hot rail?
(A) 0.8 ft (2.4 m)
(B) 2.1 ft (3.6 m)
(C) 17 ft (5.1 m)
(D) 45 ft (14 m)

8. (a) Find the force in member FC.



(A) 0.5
(B) 17
(C) 23
(D) 29

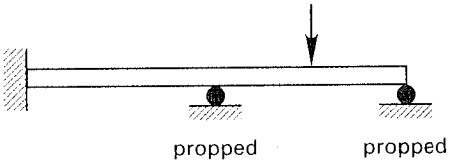
(b) What is the force in member CE?
(A) 0.50
(B) 0.63
(C) 11
(D) 17

44 Indeterminate Statics

PRACTICE PROBLEMS

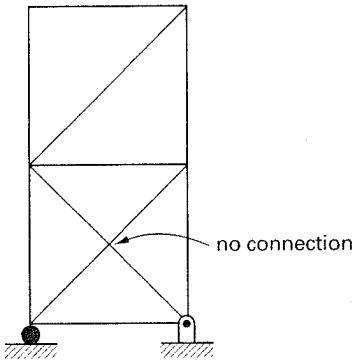
Degree of Indeterminacy

1. What is the degree of indeterminacy of the following structure?



(A) 1
(B) 2
(C) 3
(D) 4

2. What is the degree of indeterminacy of the following truss?



(A) 1
(B) 2
(C) 3
(D) 4

Elastic Deformation

3. What is the compressive load if a 1 in × 2 in × 10 in (2 cm × 5 cm × 30 cm) copper tie rod ($E = 18 \times 10^6$ lbf/in^2 (12×10^4 MPa)) experiences a 55°F (30°C) increase from the no-stress temperature?

(A) 8000 lbf (26 kN)
(B) 12,000 lbf (38 kN)
(C) 15,000 lbf (48 kN)
(D) 18,000 lbf (58 kN)

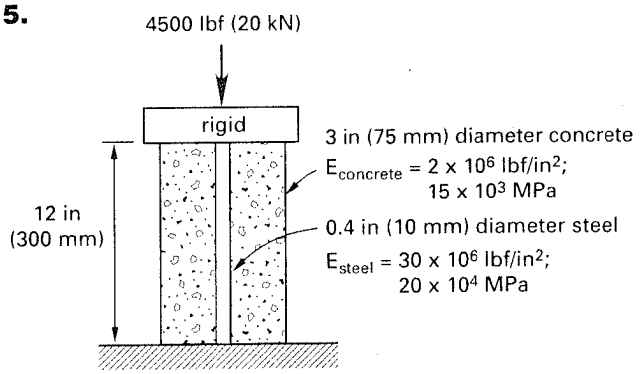
4. A 2 in diameter (5 cm diameter) and 15 in long (40 cm long) steel rod ($E = 30 \times 10^6$ lbf/in^2 (20×10^4 MPa)) supports a 2250 lbf (10 000 N) compressive load.

(a) What is the stress?
(A) 570 lbf/in^2 (4.0 MPa)
(B) 720 lbf/in^2 (5.1 MPa)
(C) 1100 lbf/in^2 (7.8 MPa)
(D) 1400 lbf/in^2 (9.9 MPa)

(b) What is the decrease in length?
(A) 8.7×10^{-5} in (2.3×10^{-6} m)
(B) 1.1×10^{-4} in (3.0×10^{-6} m)
(C) 3.6×10^{-4} in (1.0×10^{-5} m)
(D) 9.3×10^{-4} in (2.6×10^{-5} m)

Consistent Deformation Method

5.



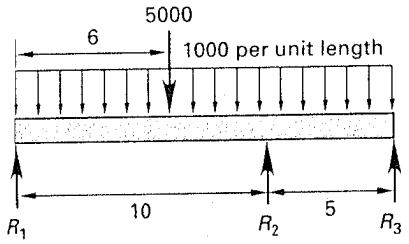
(a) Find the force and stress in each member for the structure shown.

(b) Find the total deflection for the structure shown.

6. The concentric pipe assembly shown is rigidly attached at both ends. The rigid ends are unconstrained. What is the stress generated in each pipe if the temperature of the assembly rises 200°F (110°C)?

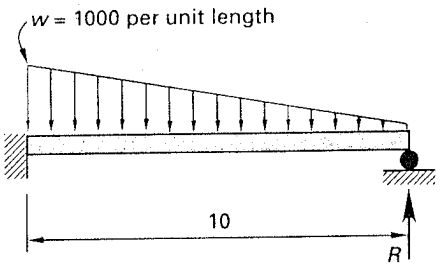
Superposition Method

11. Using the superposition method, find the intermediate support reaction, R_2, for the structure.



(A) 9000
(B) 11,000
(C) 15,000
(D) 18,000

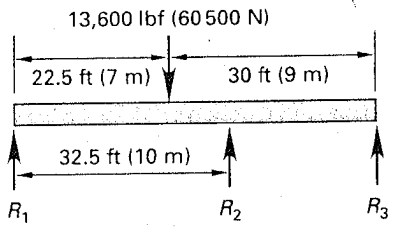
12. Using the superposition method, determine the reaction, R, at the prop.



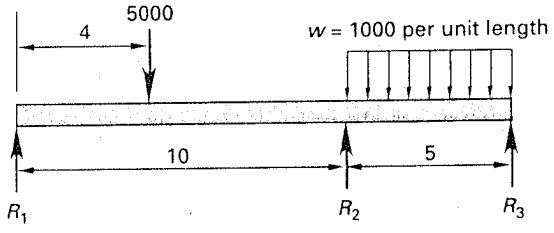
(A) 800
(B) 1000
(C) 1200
(D) 1400

Three-Moment Equation

13. What are the reactions R_1, R_2, and R_3?

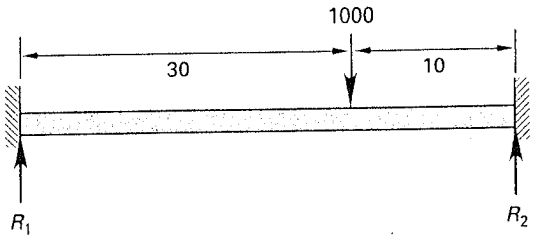


14. What are the reactions R_1, R_2, and R_3?



Fixed-End Moments

15. What are the vertical reactions at both ends of the structure?



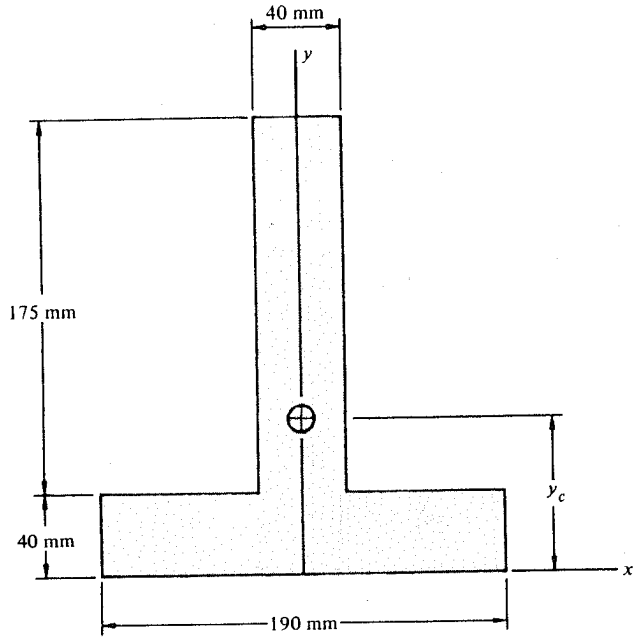


Fig. 9.6*a*

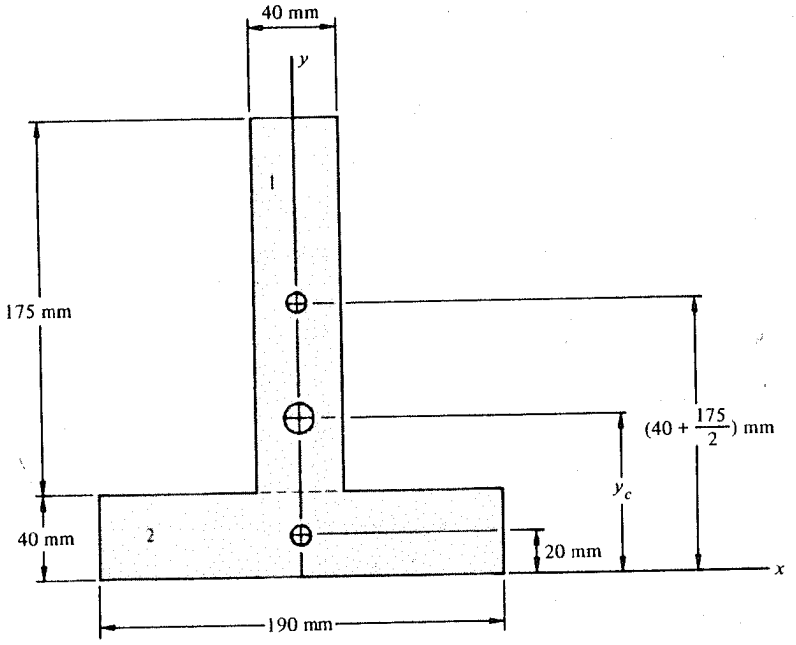


Fig. 9.6*b*

The area term is entered simultaneously in the numerator and the denominator of the centroidal coordinate equation for y_c. The effects of the terms y_2 and A_2 are then added into the numerator and denominator of the equation to obtain the final form

$$y_c = \frac{y_1A_1 + y_2A_2}{A_1 + A_2} = \frac{(40 + \frac{175}{2})40(175) + 20(190)40}{40(175) + 190(40)} = 71.5 \text{ mm}$$

The final statement of the solution is then

$$x_c = 0 \qquad y_c = 71.5 \text{ mm}$$

9.7 Find the centroidal coordinates of the area shown in Fig. 9.7*a*.

Find x_c and y_c for the area shown in Fig. 9.11*a*.

I The division of the area into elementary shapes is seen in Fig. 9.11*b*. The centroidal coordinates are then found to be

$$x_c = \frac{x_1A_1 + x_2A_2 + x_3A_3}{A_1 + A_2 + A_3} = \frac{\frac{2}{3}(713)\frac{1}{2}(713)850 + (713 + \frac{928}{2})928(850) + (713 + 928 + \frac{309}{3})\frac{1}{2}(309)850}{\frac{1}{2}(713)850 + 928(850) + \frac{1}{2}(309)850} = 1{,}060 \text{ mm}$$

$$A = 1.223 \times 10^6 \text{ mm}^2$$

$$y_c = \frac{y_1A_1 + y_2A_2 + y_3A_3}{A_1 + A_2 + A_3} = \frac{\frac{1}{3}(850)\frac{1}{2}(713)850 + \frac{850}{2}(928)850 + \frac{1}{3}(850)\frac{1}{2}(309)850}{1.223 \times 10^6} = 375 \text{ mm}$$

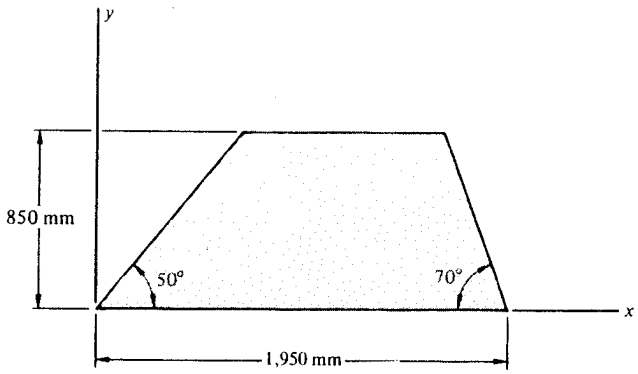


Fig. 9.11*a*

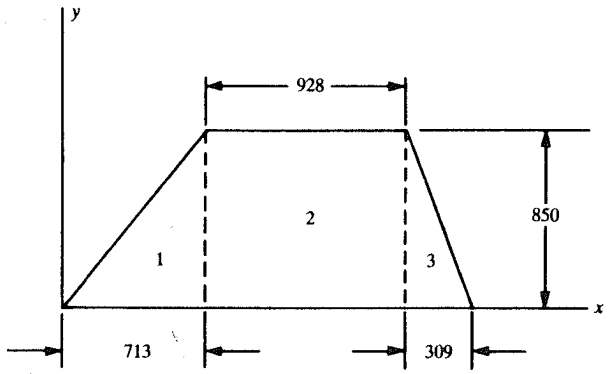


Fig. 9.11*b*

2 Find the centroidal coordinates of the area shown in Fig. 9.12*a*.

I The division of the given area is shown in Fig. 9.12*b*. The centroidal coordinates of area 1 are found by using Case 7 in Table 9.9, with the results

$$x_1 = 3 - \frac{4a}{3\pi} = 3 - \frac{4(3)}{3\pi} \qquad y_1 = 13 + \frac{4a}{3\pi} = 13 + \frac{4(3)}{3\pi}$$

x_c and y_c are then found to be

$$x_c = \frac{x_1A_1 + x_2A_2 + x_3A_3}{A_1 + A_2 + A_3} = \frac{[3 - 4(3)/3\pi]\frac{1}{4}\pi(3)^2 + \frac{3}{2}(3)13 + (3 + \frac{3}{2})3(4)}{\frac{1}{4}\pi(3)^2 + 3(13) + 3(4)} = 2.15 \text{ in}$$

$$A = 58.07 \text{ in}^2$$

$$y_c = \frac{y_1A_1 + y_2A_2 + y_3A_3}{A_1 + A_2 + A_3} = \frac{[13 + 4(3)/3\pi]\frac{1}{4}\pi(3)^2 + \frac{13}{2}(3)13 + \frac{4}{2}(3)4}{58.07} = 6.52 \text{ in}$$

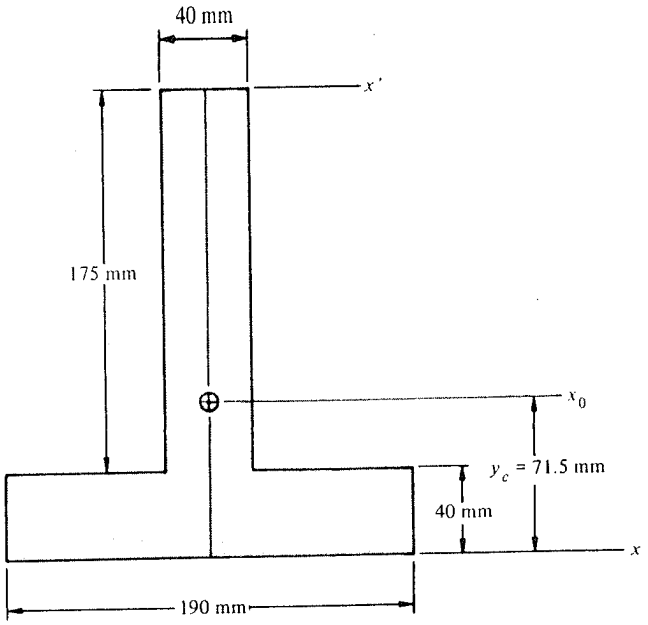


Fig. 10.13*a*

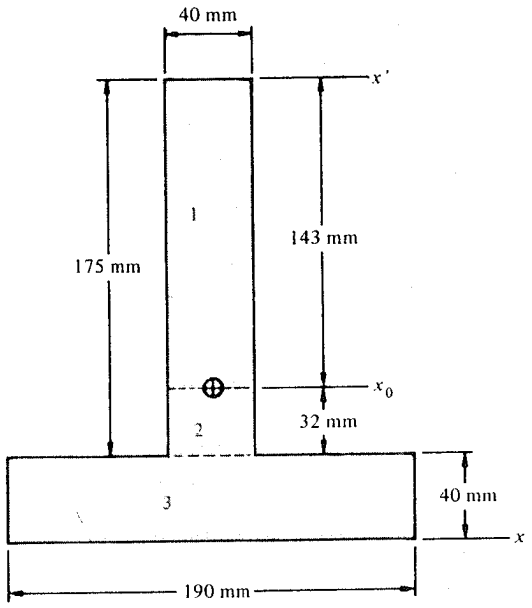


Fig. 10.13*b*

found directly, by using Case 2 of Table 10.6, as moments of inertia of a rectangle about its edge. The moment of inertia of area 3 about the x_0 axis is found by using the parallel-axis theorem. The result for I_{0x}, the moment of inertia of the cross-sectional area about the x_0 axis, is then

$$I_{0x} = I_{01} + I_{02} + I_{03} = \frac{40(143)^3}{3} + \frac{40(32)^3}{3} + \left[\frac{190(40)^3}{12} + (190)(40)(32+20)^2\right] = 6.10 \times 10^7 \text{ mm}^4$$

The moment of inertia I_x may be found next by using the above result for the moment of inertia about the centroidal axis together with the parallel-axis theorem. This result is

$$I_x = I_{0x} + A\,d_x^2 = 6.10 \times 10^7 + [40(175) + 190(40)](71.5)^2 = 1.36 \times 10^8 \text{ mm}^4$$

In a similar fashion, the moment of inertia $I_{x'}$ about the x' axis is found to be

$$I_{x'} = I_{0x} + A\,d_x^2 = 6.10 \times 10^7 + [40(175) + 190(40)](143)^2 = 3.60 \times 10^8 \text{ mm}^4$$

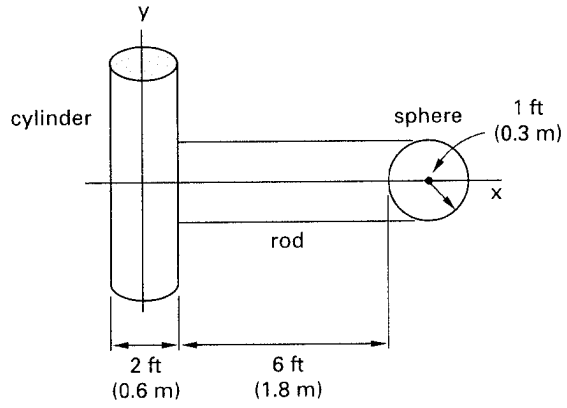
10.14 (*a*) Find the moments of inertia I_x and I_y of the area shown in Fig. 10.14*a*.

54 Properties of Solid Bodies

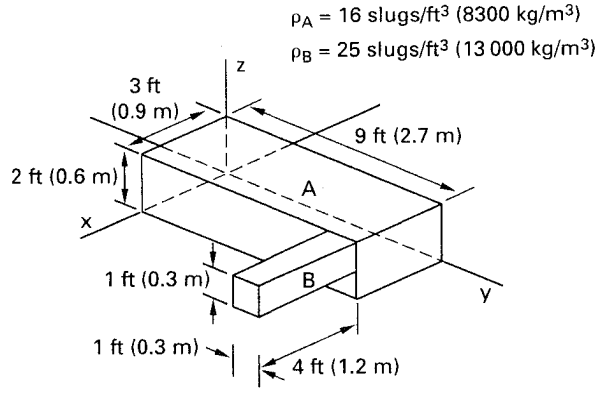
PRACTICE PROBLEMS

Center of Gravity

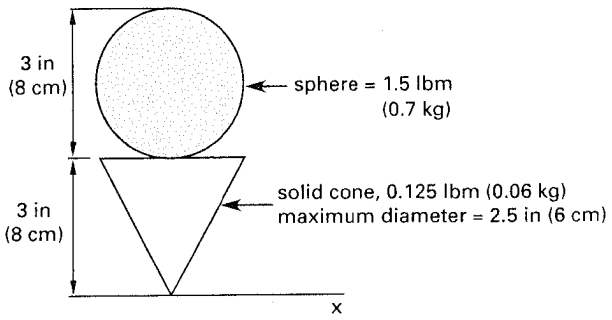
1. Locate the center of gravity if the weights of the sphere, rod, and cylinder are 64.4, 32.2, and 64.4 pounds (29.2, 14.6, and 29.2 kg), respectively.



2. Find the center of gravity of the object shown.



3. Find the center of gravity with respect to the x-axis of the object shown.

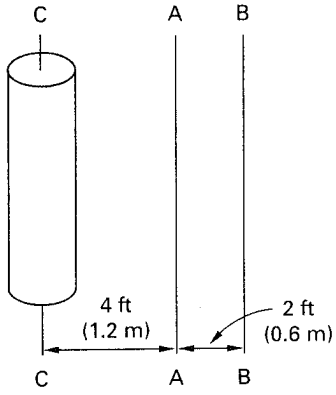


Mass Moments of Inertia

4. What is the mass moment of inertia about the x-axis of the object shown in problem 2?

5. What is the mass moment of inertia about the x-axis for the object shown in problem 3?

6. Find the moment of inertia about the BB axis if I_{AA} is 90 slug-ft^2 (120 kg·m^2) and the mass is 64.4 pounds (29.2 kg).



7. A spoked flywheel has an outside diameter of 60 in (1500 mm). The rim thickness is 6 in (150 mm), and the width is 12 in (300 mm). The cylindrical hub has an outside diameter of 12 in (300 mm), a thickness of 3 in (75 mm), and a width of 12 in (300 mm). The rim and hub are connected by six equally spaced cylindrical radial spokes, each with a diameter of 4.25 in (110 mm). All parts of the flywheel are ductile cast iron with a density of 0.256 lbm/in^3 (7080 kg/m^3). What

55 Kinematics

PRACTICE PROBLEMS

Linear Particle Motion

1. A particle moves horizontally according to $s = 2t^2 - 8t + 3$.

(a) When $t = 2$, what are the position, velocity, and acceleration?

(b) What are the linear displacement and total distance traveled between $t = 1$ and $t = 3$?

Uniform Acceleration

2. A jet plane acquires a speed of 180 mph (290 km/h) in 60 seconds. What is its acceleration?

(A) 4.4 ft/sec^2 (1.3 m/s^2)
(B) 6.3 ft/sec^2 (1.9 m/s^2)
(C) 8.9 ft/sec^2 (2.7 m/s^2)
(D) 12 ft/sec^2 (3.6 m/s^2)

UNITS!

3. What is the acceleration of a train that increases its speed from 5 ft/sec to 20 ft/sec (1.5 m/s to 6 m/s) in 2 minutes?

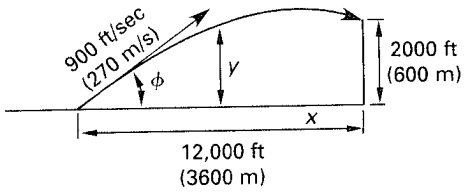
(A) 0.13 ft/sec^2 (0.038 m/s^2)
(B) 0.39 ft/sec^2 (0.12 m/s^2)
(C) 0.82 ft/sec^2 (0.25 m/s^2)
(D) 1.3 ft/sec^2 (0.39 m/s^2)

4. A car traveling at 60 mph (100 km/h) applies its brakes and stops in 5 seconds. What is its acceleration and distance traveled before stopping?

Projectile Motion

5. A projectile is fired at 45° from the horizontal with an initial velocity of 2700 ft/sec (820 m/s). Find the maximum altitude and range neglecting air friction.

6. A projectile is launched with an initial velocity of 900 ft/sec (270 m/s). The target is 12,000 ft (3600 m) away and 2000 ft (600 m) higher than the launch point. Air friction is to be neglected. At what angle should the projectile be launched?



7. A baseball is hit at 60 ft/sec (20 m/s) and 36.87° from the horizontal. It strikes a fence 72 feet (22 m) away. Find the velocity components and the elevation above the origin at impact.

8. A bomb is dropped from a plane that is climbing at 30° and 600 ft/sec (180 m/s) while traveling at 12,000 feet (3600 m) altitude.

(a) What is the bomb's maximum altitude?

(A) 12,500 ft (3700 m)
(B) 13,000 ft (3900 m)
(C) 13,400 ft (4000 m)
(D) 14,200 ft (4300 m)

(b) How long will it take for the bomb to reach the ground from the release point?

(A) 24 sec
(B) 38 sec
(C) 43 sec
(D) 55 sec

Rotational Particle Motion

9. A point travels in a circle according to $\omega = 6t^2 - 10t$. At $t = 2$, the direction of motion is clockwise.

(a) What is the angular velocity at $t = 2$?

(A) 4
(B) 6
(C) 8
(D) 12

(b) What is the displacement between $t = 1$ and $t = 3$?

(A) 6 rad
(B) 10 rad
(C) 12 rad
(D) 15 rad

(c) What is the total angle turned through between $t = 1$ and $t = 3$? Assume $\theta(0) = 0$.

(A) 6 rad
(B) 8 rad
(C) 12 rad
(D) 15 rad

10. What is the linear speed of a point on the edge of a 14-inch-diameter (36-cm-diameter) disk turning at 40 rpm?

(A) 2.4 ft/sec (0.75 m/s)
(B) 4.5 ft/sec (1.4 m/s)
(C) 7.8 ft/sec (2.3 m/s)
(D) 9.2 ft/sec (2.8 m/s)

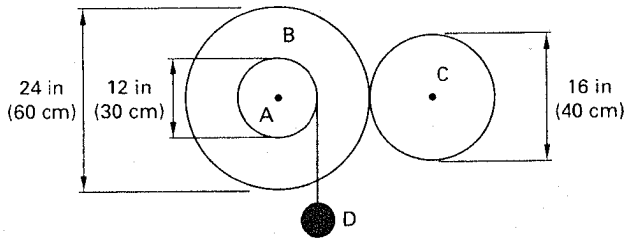
11. What angular acceleration is required to increase an electric motor's speed from 1200 rpm to 3000 rpm in 10 seconds?

(A) 10 rad/sec^2
(B) 14 rad/sec^2
(C) 18 rad/sec^2
(D) 25 rad/sec^2

12. An apparatus for determining the speed of a bullet consists of 2 paper disks mounted 5 feet (1.5 m) apart on a single horizontal shaft which is turning at 1750 rpm. A bullet pierces both disks at radius 6 inches (15 cm) and an angle of 18° exists between each hole. What is the bullet velocity?

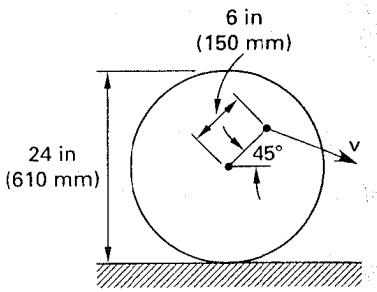
(A) 1700 ft/sec (510 m/s)
(B) 2100 ft/sec (630 m/s)
(C) 2400 ft/sec (720 m/s)
(D) 2900 ft/sec (880 m/s)

13. Disks B and C are in contact and rotate without slipping. A and B are splined together and rotate counterclockwise. Angular velocity and acceleration of disk C are 2 rad/sec (2 rad/s) and 6 rad/sec^2 (6 rad/s^2), respectively. What is the velocity and acceleration of point D?



Relative Motion

14. The center of a wheel with an outer diameter of 24 in (610 mm) is moving at 28 mi/hr (12.5 m/s). There is no slippage between the wheel and surface. A valve stem is mounted 6 in (150 mm) from the center. What are the velocity and direction of the valve stem when it is 45° from the horizontal?

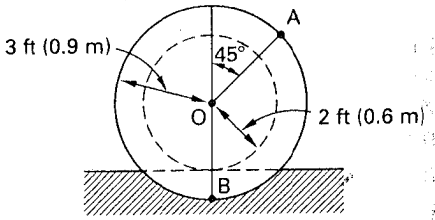


15. A balloon is 200 feet (60 m) above the ground and is rising at a constant 15 ft/sec (4.5 m/s). An automobile passes under it traveling along a straight and level road at 45 mph (72 km/h). How fast is the distance between them changing one second later?

(A) 13 ft/sec (4.0 m/s)
(B) 34 ft/sec (10 m/s)
(C) 37 ft/sec (11 m/s)
(D) 51 ft/sec (15 m/s)

Rotation About a Fixed Axis

16. Find the velocities of points A and B with respect to point O if the wheel rolls without slipping. The axle to which the wheel is attached moves at 10 ft/sec (3 m/s) to the right.



17. What is the velocity of point B with respect to point A in problem 16?

56 Kinetics

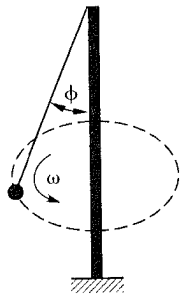
PRACTICE PROBLEMS

Centripetal and Centrifugal Forces

1. Calculate the superelevation in percent necessary on a curve with a 6000-foot (1800-m) radius so that at 60 mph (100 km/h) cars will not have to rely on friction to stay on the roadway.

(A) 4%
(B) 7%
(C) 11%
(D) 14%

2. What is the angle between the pole and the wire if the radius of the path is 4 feet (1.2 m)? The 8.05-pound (3.65-kg) object is rotating at 20 ft/sec (6 m/s).



(A) 46°
(B) 58°
(C) 72°
(D) 79°

3. A 10-pound (5-kg) mass is tied to a 2-ft (50-cm) string and whirled at 5 revolutions per second horizontally to the ground.

(a) Find the centripetal acceleration.
(A) 1400 ft/sec^2 (350 m/s^2)
(B) 1600 ft/sec^2 (400 m/s^2)
(C) 1800 ft/sec^2 (450 m/s^2)
(D) 2000 ft/sec^2 (490 m/s^2)

(b) Find the centrifugal force.
(A) 490 lbf (1900 N)
(B) 610 lbf (2500 N)
(C) 750 lbf (2900 N)
(D) 820 lbf (3100 N)

(c) Find the centripetal force.
(A) 490 lbf (1900 N)
(B) 610 lbf (2500 N)
(C) 750 lbf (2900 N)
(D) 820 lbf (3100 N)

(d) Find the angular momentum.
(A) 39 ft-lbf-sec (39 J·s)
(B) 44 ft-lbf-sec (44 J·s)
(C) 53 ft-lbf-sec (53 J·s)
(D) 71 ft-lbf-sec (71 J·s)

Friction

4. A 100-pound (50-kg) body has an initial velocity of 12.88 ft/sec (3.93 m/s) while moving on a plane with coefficient of friction of 0.2. What distance will it travel before coming to rest?

(A) 13 ft (3.9 m)
(B) 15 ft (4.5 m)
(C) 18 ft (5.4 m)
(D) 24 ft (7.2 m)

5. A box is dropped onto a conveyor belt moving at 10 ft/sec (3 m/s). The coefficient of friction between the box and the belt is 0.333. How long will it take before the box stops slipping on the belt?

(A) 0.48 sec
(B) 0.67 sec
(C) 0.93 sec
(D) 1.2 sec

6. A motorcycle and rider weigh 400 pounds (200 kg). They travel horizontally around the inside of a hollow, right-angle cylinder of 100 feet (30 m) inside diameter. What is the coefficient of friction that will allow a speed of 40 mph (60 km/h)?

(A) 0.3
(B) 0.4
(C) 0.5
(D) 0.6

7. When a force acts on a 10-pound (5-kg) body initially at rest, a speed of 12 ft/sec (3.6 m/s) is attained in 36 feet (11 m). What is the force if the coefficient of friction is 0.25 and the acceleration is constant?

(A) 1.8 lbf (8.6 N)
(B) 2.4 lbf (13 N)
(C) 3.1 lbf (15 N)
(D) 4.6 lbf (22 N)

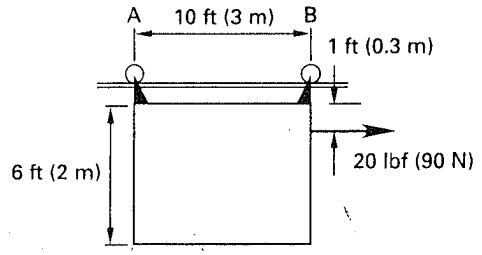
8. A 130-pound (60-kg) block slides up a 22.62° incline with coefficient of friction of 0.1 and initial velocity of 30 ft/sec (9 m/s). How far will the block slide up the incline before coming to rest?

(A) 18 ft (5.4 m)
(B) 29 ft (8.7 m)
(C) 42 ft (13 m)
(D) 57 ft (17 m)

9. A 100-pound (50-kg) block is acted upon by a 100-pound (400-N) force while resting on a horizontal surface with coefficient of friction of 0.2. A 50-pound (25-kg) block sits on top of the 100-pound (50-kg) block. What is the minimum coefficient of friction between the 50- and 100-pound (25- and 50-kg) blocks for there to be no slipping?

Rigid Body Motion

10. A constant force of 20 pounds (90 N) is applied to a 100-pound (50-kg) door supported on rollers at A and B.



(a) What is the acceleration of the door?

(b) What are the reactions at A and B?

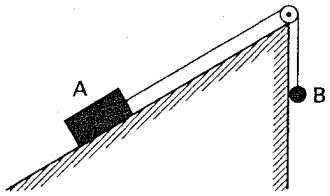
(c) Where would the 20 lbf (90-N) force have to be applied if the reactions at A and B were to be equal?

Constrained Motion

11. A solid sphere rolls without slipping down a 30° incline, starting from rest. What is its speed after two seconds?

(A) 17 ft/sec (5.1 m/s)
(B) 23 ft/sec (7.0 m/s)
(C) 34 ft/sec (10 m/s)
(D) 86 ft/sec (26 m/s)

12. Object A weighs 10 pounds (5 kg) and rests on a frictionless plane with a 36.87° slope. Object B weighs 20 pounds (10 kg). What is the velocity of B three seconds after release?



(A) 14 ft/sec (4.2 m/s)
(B) 22 ft/sec (6.6 m/s)
(C) 38 ft/sec (11 m/s)
(D) 45 ft/sec (14 m/s)

Impulse and Momentum

13. Sand drops at the rate of 560 lbm/min (250 kg/min) onto a conveyor belt moving with a velocity of 3.2 ft/sec (0.98 m/s). What force is required to keep the belt moving?

(A) 0.93 lbf (4.1 N)
(B) 1.2 lbf (5.3 N)
(C) 2.3 lbf (10 N)
(D) 4.8 lbf (14 N)

14. What is the impulse imparted to a 0.4-pound (0.2-kg) baseball that approaches the batter at 90 ft/sec (30 m/s) and leaves at 130 ft/sec (40 m/s)?

(A) 1.8 lbf-sec (9.4 N·s)
(B) 2.7 lbf-sec (14 N·s)
(C) 4.1 lbf-sec (21 N·s)
(D) 8.9 lbf-sec (46 N·s)

15. At what velocity will a 1000-lbm (500-kg) gun mounted on wheels recoil if a 2.6-lbm (1.2-kg) projectile is propelled to 2100 ft/sec (650 m/s)?

(A) 3.7 ft/sec (1.1 m/s)
(B) 4.8 ft/sec (1.4 m/s)
(C) 5.5 ft/sec (1.6 m/s)
(D) 15 ft/sec (4.5 m/s)

16. A 0.15 lbm (60-g) bullet traveling 2300 ft/sec (700 m/s) embeds itself in a 9-lbm (4.5-kg) wooden block. What will be the block's initial velocity?

(A) 24 ft/sec (7.2 m/s)
(B) 38 ft/sec (9.2 m/s)
(C) 66 ft/sec (200 m/s)
(D) 110 ft/sec (330 m/s)